Volume 15 May, 1929 *Number 5*

Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Lubrication of Cement Mill Machinery

PUBLISHED MONTHLY BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS

Texaco Lubricants for Cement Mill Machinery

Crushing and Grinding Machinery

JAW CRUSHERS

Pitman Bearings	
(*Waste Pad Lubricated*)	TEXACO PINNACLE CYL. OIL TEXACO PELICAN OIL OR
According to Temperatures	TEXACO STAR GREASE B
(*Grease Cup Lubricated*)	TEXACO CUP GREASE NO. 3, NO. 5 OR TEXACO MARFAK GREASE NO. 3
Eccentric and Other Wearing Parts	
(*Oil Lubricated*)	TEXACO CRUSHER OIL OR TEXACO PELICAN OIL
(*Grease Lubricated*)	TEXACO STAR GREASE B OR
According to Means Provided	TEXACO CUP GREASE NO. 3 OR NO. 5

GYRATORY CRUSHERS

Eccentric Bearings, Gears, Ball Bearings and Countershaft	
(*Warm Weather Operation*)	TEXACO CRUSHER OIL OR TEXACO 747 OIL
(*Cold Weather Operation*)	TEXACO ALGOL OIL OR TEXACO TEXOL OIL E OR X
Suspension and Wearing Rings (*at Top of Main Shaft*)	TEXACO CRUSHER OIL
(*Grease Lubrication*)	TEXACO STAR GREASES

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(*Grease Lubricated*)	TEXACO CUP GREASE NO. 3 OR NO. 5

BALL, TUBE AND COMPEB MILLS

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According to Temperature	TEXACO HYTEX GREASE NO. 5
Ring Oiled Shaft Bearings	TEXACO CANOPUS OIL OR TEXACO CETUS OR ALCAID OIL
Trunnion Bearings (*Wool Yarn Packed*)	TEXACO STAR GREASE B OR TEXACO CRUSHER OIL
(*Otherwise*)	TEXACO HYTEX GREASE NO. 5
Thrust Bearings, etc. (*Bath Lubricated*)	TEXACO PINNACLE CYL. OIL
Gears and Pinions	TEXACO THUBAN COMPOUND OR TEXACO CRATER COMPOUND NO. 1

For TEXACO Recommendations for Dryer, Kiln and Conveyor Equipment, see inside Back Cover.

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Lubrication of Cement Mill Machinery

THE magnitude of the cement industry, and the important bearing which it has upon the production of allied industries, are but little realized by many of us, for the use of concrete for building and highway construction purposes has been altogether too casually accepted. It is a huge industry and worthy of decided study, for the average man should certainly appreciate the extent to which his comforts, his transportation and his particular line of endeavor are contingent upon the use of cement.

While there is more or less of a direct tie-up between the cement industry and virtually every other phase of manufacture today, perhaps the most interesting feature is the extent to which the production of cement depends upon petroleum products.

In 1926, for example, some 44,800,000* pounds of lubricating oil and grease were used in the production of cement, for the mere reduction of friction on the machinery involved. Furthermore, in the neighborhood of 5,000,000 tons of fuel oil were used in connection with drying and burning of the product after pulverization. To meet the requirements of construction, over 164,000,000 barrels of cement were produced during this same period.

The manufacture of cement is unique in that it involves a very low-priced raw material. Treatment and handling of this latter, however, must be extensive; hence, the value of the finished product. The power consumed in the several processes of handling and grinding must, of necessity, be high, due to the heavy duty required of the machinery.

Lubrication must, therefore, be carefully studied, for it will be the ultimate criterion in determination of power costs and production efficiency. Failure of a gyratory, for example, or a conveyor pump or kiln tied up, due to impaired lubrication, may easily lead to disruption of a production schedule which might seriously interfere with fulfillment of orders and meeting of competition.

PROCESSES INVOLVED

Portland Cement is manufactured by
the dry process,
the semi-dry process, or
the wet process.

While these will vary somewhat, according to the type of raw materials used, the general machinery employed will be very much the same, with the exception that in the wet and semi-dry process provision must be made for pumping the "slurry" to the various grinding mills and storage tanks prior to evaporation and burning. Pumps take the place of conveyors in such systems.

FUNCTION OF THE MACHINERY

In view of the fact that this study of cement mill lubrication will deal distinctly with the mill itself, only the machinery involved therein will be discussed. This can normally be grouped into four broad classifications, according to the duty required, i.e.,

Crushing and grinding,
Kiln treatment or burning,
Cooling and pulverizing, and
Conveying and packing.

*Portland Cement Association.

CRUSHING AND GRINDING

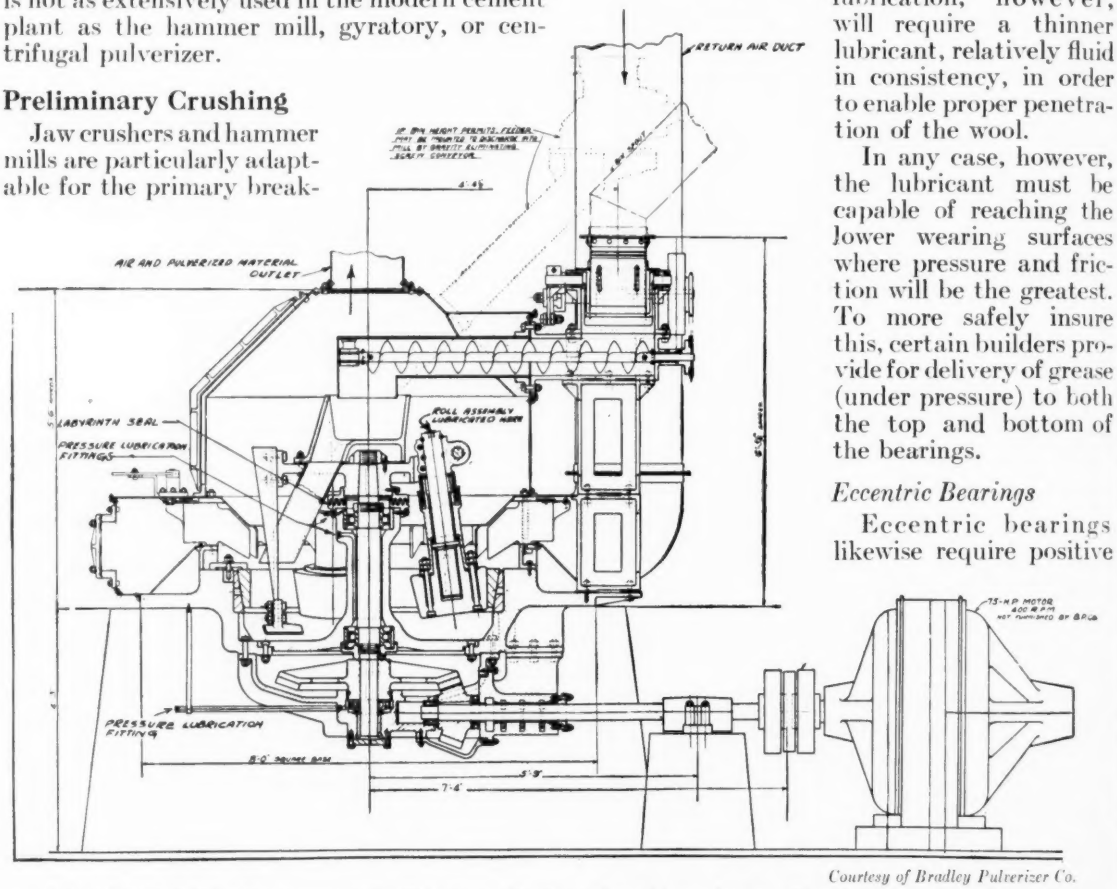
As a general rule, crushing and grinding may be regarded as involving two distinct operations:

1. The preliminary reduction in size of the raw material, and
2. The finished pulverization of the product.

The first step is to deliver the raw product to the jaw crusher, hammer mill, or gyratory. Because of the limited capacity, the jaw crusher is not as extensively used in the modern cement plant as the hammer mill, gyratory, or centrifugal pulverizer.

Preliminary Crushing

Jaw crushers and hammer mills are particularly adaptable for the primary breaking of the raw products as they come from the quarry.



Courtesy of Bradley Pulverizer Co.

Fig. 1—Details of the Bradley pneumatic mill. This is a centrifugal type of gear driven pulverizer. Of particular interest are the grinding rolls. These latter are oil lubricated according to the detail which is shown in Fig. 8. Note that other parts of this mill have provision for pressure grease lubrication. The gears operate in a bath of oil.

Lubrication of the jaw crusher is essentially confined to the bearings of the pitman and eccentric shaft. The former carry the pitman or heavy steel casting which oscillates with its bearing as the point of suspension to bring about the requisite degree of crushing. As a rule the pitman bearing is water cooled; in addition, in certain larger crushers it is relieved of much of the weight by the use of links and coiled springs, for the potential friction involved is considerable.

As a result, lubrication of the pitman bearing is of decided importance. Grease is very often the most adaptable lubricant, being applied to the bearing either by means of pressure lubricators or via reservoirs equipped with wool waste or some other form of pad retainer to insure positive lubrication without undue loss.

Where pressure lubrication is employed, a medium to heavy cup grease will frequently serve the purpose. The use of wool or pad lubrication, however, will require a thinner lubricant, relatively fluid in consistency, in order to enable proper penetration of the wool.

In any case, however, the lubricant must be capable of reaching the lower wearing surfaces where pressure and friction will be the greatest. To more safely insure this, certain builders provide for delivery of grease (under pressure) to both the top and bottom of the bearings.

Eccentric Bearings

Eccentric bearings likewise require positive lubrication. Unless the weight of the pitman is more or less balanced by springs, etc., its weight will be exerted upon the eccentric shaft bearings, with the probable result that the lubricant will be unable to penetrate and maintain the requisite friction-reducing film between the shaft and bearings.

The construction of the crusher must, therefore, always be taken into consideration; where springs and links are used to balance the pitman, pad lubrication using a light grease will probably work out satisfactorily. Where the weight of the pitman is exerted on the eccentric bearings, as well as on its own sup-

ports, pressure lubrication with a heavier grease will be more in line.

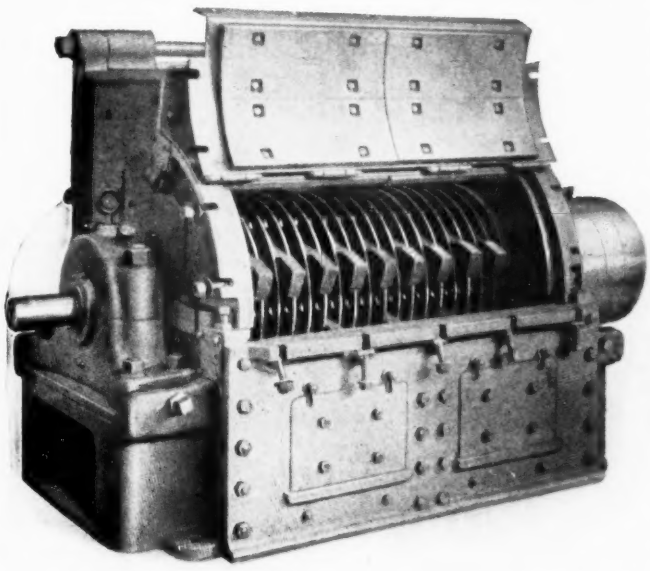
Hammer Mills

In mills of this type the material is crushed as it passes between the hammer elements or rolls and the grinding ring, being subsequently thrown to a hopper at the bottom of the machine. From this point the product in some mills is passed to external screens where all over-size particles are separated and returned to the mill for further reduction.

The points requiring lubrication will depend on the type of mill. In general, however, there will be the roll shaft bearings, and in certain machines, the hammer roll bearings, the pinion shaft bearings and the gears.

Certain hammer rolls are mounted upon roller bearings, being enclosed in dust-proof housings. They normally operate in a bath of oil, the source of which is a large reservoir fixed to the end of the hammer roll shaft. The oil to use for this purpose should be a neutral, straight mineral product, of sufficient viscosity to insure adequate body and the prevention of metallic contact at the operating temperatures. Where plain bearings are involved, however, a medium to heavy grease should be used.

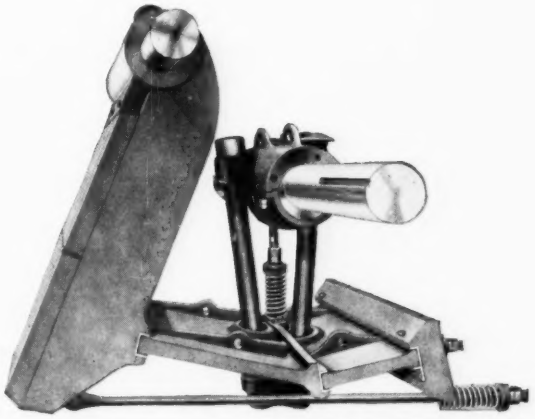
The pinion shaft, where a gear drive is involved, operates at a somewhat higher speed than the ring shaft, but the same provisions are made for lubrication with, therefore, usage of the same lubricant.



Courtesy of Jeffrey Mfg. Co.

Fig. 2—Showing the Jeffrey type "B" ball bearing swing hammer pulverizer. Note the manner of locating the hammers on the shaft.

The gears of such mills are enclosed and consequently dust will not involve the same problem as in the case of the kilns or tube mills. In addition, they are not exposed to high temperatures. They are normally operated in a bath of light gear lubricant. This latter should, of course, possess sufficient adhesiveness to withstand the throwing-off action of centrifugal force.



Courtesy of Traylor Eng. & Mfg. Co.

Fig. 3—The toggle mechanism and swing jaw of a bulldog jaw crusher. This particular type is distinctive and advantageous, in that no lubrication is required for the toggle seats, inasmuch as rolling action alone is involved.

Other types of hammer mills and ring grinders provide for driving of the top hammer roll instead of the ring. This is brought about by means of a pulley, or directly by a motor. The movement of the top roll causes the ring to revolve, to in turn impart motion to the lower rolls.

The only points requiring lubrication on such mills are the two bearings on each of the hammer roll shafts. These bearings are long and are fitted with collars for excluding dust. Each bearing is equipped with a large reservoir capable of holding a quantity of grease.

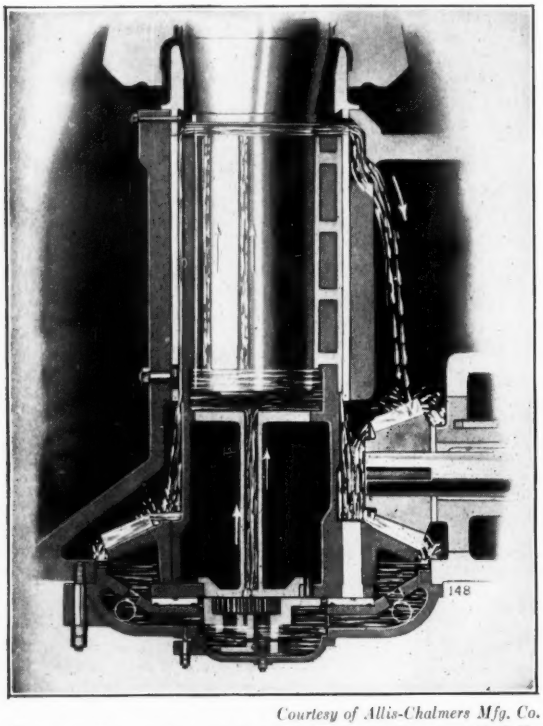
Centrifugal Mills

Mills involving rotating balls, or centrifugally operated rolls are also adaptable for preparing material for the kilns, as well as for final grinding.

In such a mill a set of balls, or rolls, move around the internal circumference of a wearing ring or die. Considerable pressure against the die is thereby brought about, especially in the centrifugal roll mill; the material is ground between the rolling elements and this die.

The main shaft bushings of such mills may

be lubricated with either a heavy oil or grease. The intermediate bearing of the ball type mill however, because of its inaccessibility, is most conveniently lubricated with grease. The lower bushing and thrust bearing are arranged to operate in a bath of oil.



Courtesy of Allis-Chalmers Mfg. Co.

Fig. 4—Bottom section of the Allis-Chalmers Superior McCully Crusher, showing the automatic lubrication of eccentric and gears. Note that lubrication is effected by means of an oil pump located in the oil chamber in the bottom plate. This is an entirely automatic system of lubrication, resulting in continuous flow of oil through the inside eccentric bearing, and down through suitable oil grooves in the outer bearing. Surplus oil is diverted through an opening in the centre hub to the gears.

Steam cylinder or crusher oil may be used successfully for such lubrication, but when the gear drive and ball thrust bearing are incorporated in the same housing, only lubricants suitable for ball bearing lubrication should be employed.

The driving gears, which are used upon some types of such mills, may be successfully operated in a bath of light gear lubricant or medium viscosity oil. Where grit may get into the gear case, this method of lubrication is not as satisfactory, however, as the use of a more viscous product, ranging up to 1000 seconds Saybolt viscosity at 210 degrees Fahr.

Roll Shaft Lubrication

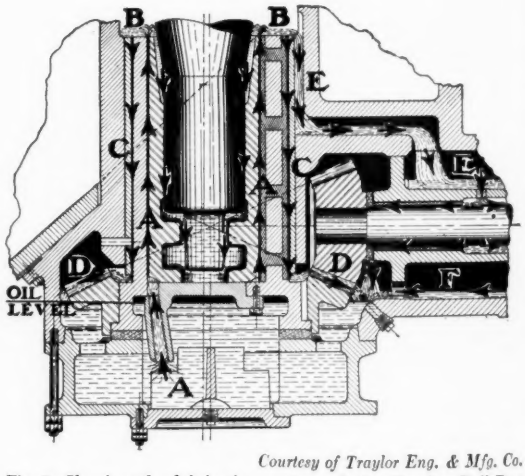
In the operation of the centrifugal mill, a problem is involved in the maintenance of lubrication of the roll shaft bearings. Pressures on these bearings may be comparatively high, some rollers weighing as much as seventeen hundred pounds.

Where grease is used, the course of the lubricant is by gravity from the reservoir in the top of the journal housing, to the clearance space between the shaft and its bushing. This clearance is comparatively low, for rigidity in the operation of such rolls is important.

As a result, the lubricant must be capable of constantly maintaining an effective film within the clearance space; furthermore, it should not tend to leak past the grease seal at the base of the bushing.

It is practicable to use either grease or oil for the lubrication of the above. Construction of some mills of this type calls for grease lubrication, the procedure being to fill the reservoir at the top of the housing at regular intervals, depending upon the nature of the grease, the extent of vibration and the operating temperature. As a general rule, a fairly solid grease will best serve the purpose, especially if its oil content is of sufficiently high viscosity to insure a lubricating film capable of withstanding the pressures involved, and any vibration which may be developed.

Where it is desirable to use oil as the lubricant, provision for storage and adequate delivery or circulation to the roll shaft bearings will be necessary. Frequently, this latter is automatically developed by centrifugal action via suitable grooving cut around the base of the roll shaft.



Courtesy of Traylor Eng. & Mfg. Co.

Fig. 5—Showing the lubrication system of the Traylor Bull-Dog Finishing Gyratory Crusher. Oil flow is indicated by arrows. The upward stream starts at "A". It is carried up the inside of the eccentric by continuous spiral grooves in the outer surface of the lower shaft sleeve, overflowing at "B". There is no pump involved, oil being circulated by capillary attraction and the scraping action of the spiral grooves. The outside of the eccentric is lubricated at "C", the oil finally lubricating the gears shown at "D". "E" is an overflow, which delivers oil to the countershaft bearing, oil returning to the reservoir via "F".

Gyratory Crushers

Crushing is brought about in the gyratory by the circular rolling motion of the crushing head, which is actuated by gearing or belt drive through an eccentric at the bottom of the shaft. By this action the head receives circular rolling motion, successively approaching every point of the interior of the throat. This action results in a continuous breaking of the material which subsequently falls through at that point of the throat from which the head is most distant.

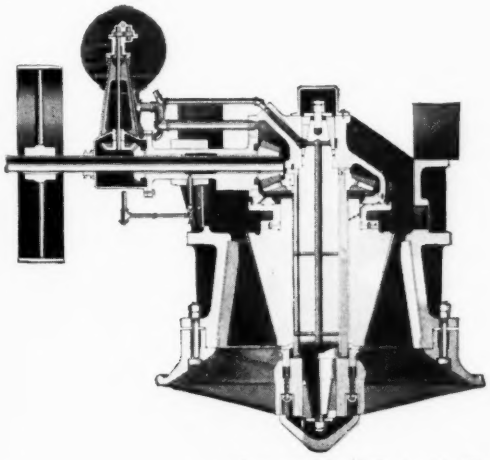
To the casual observer, a gyratory crusher will frequently give a misimpression as to the extent to which its operation depends upon lubrication. Many will be led to believe that lubrication is a relatively simple matter. This is far from true, however. In fact, due to the peculiarities of construction, and the heavy duty involved, gyratory lubrication is oftentimes a matter of considerable difficulty. Not only are the bearings frequently exposed to a great deal of grit and dust, but some of them also carry tremendous loads and occasionally are subject to extremes of temperatures.

Construction Details

Gyratory crushers may be divided into two broad classes, viz.:

(a) The geared drive type, and
(b) The gearless type.

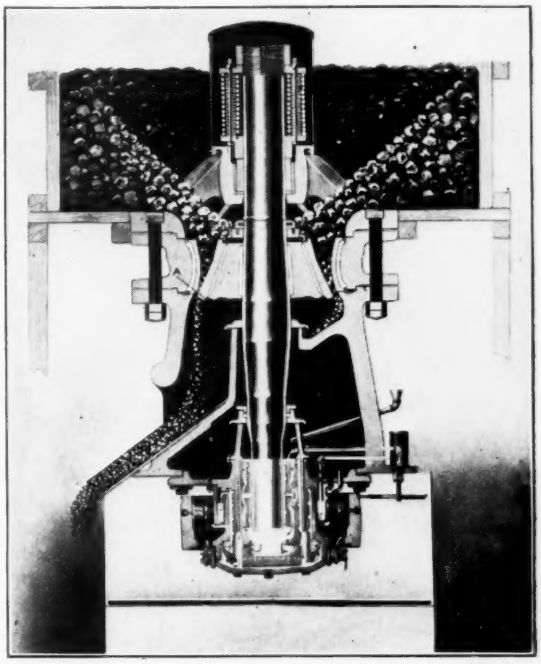
The gear driven crusher has two points requiring lubrication which are not found on those employing the gearless drive. These are the countershaft bearings and the teeth of the gears.



Courtesy of Smith Engineering Works.

Fig. 6—Sectional view of the Telsmith Primary Breaker, showing method of lubrication. Ball bearings are pressure lubricated by means of a gear oil pump. It is interesting to note that this machine requires a comparatively fluid oil.

Countershaft bearings are sometimes of the ring-oiled type, but because of the loads which they are forced to carry, to say nothing of the grit which gets into the bearings, this is oftentimes an unnecessary refinement. The speed of such bearings rarely exceeds 600 R.P.M. and consequently they can be quite adequately lubricated with cups, provided the proper grade of oil is used.



Courtesy of Kennedy-Van Saun Mfg. & Eng. Corp.

Fig. 7—Showing the Kennedy Ball Bearing Gearless Gyratory Crusher. Note that this machine is equipped with a continuous return system of lubrication, including an oil filter to insure continued maintenance of delivery of clean oil. Flow of this latter is indicated by arrows.

The ring-oiled bearing, however, has a decided advantage in that the grit is washed from the journal and carried into the reservoir. This latter, on the other hand, must be of adequate capacity. Furthermore, it must be cleaned frequently, otherwise grit will accumulate, to ultimately result in serious abrasion of the journal and bearing due to impaired lubrication.

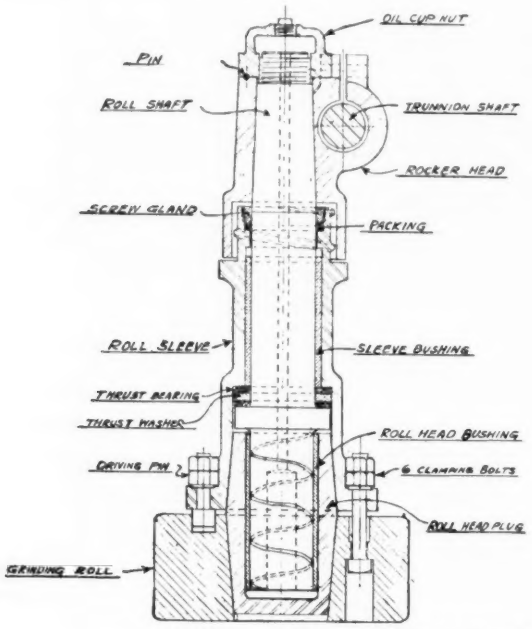
Wherever possible, countershafts should be fitted with outboard bearings, as these steady the shaft and take a great deal of load off the main bearing. A heavy engine or machine oil with a viscosity range of from 500 to 900 seconds Saybolt at 100 degrees Fahr. will usually prove successful in the average countershaft bearing of a gyratory crusher.

Gear Lubrication

In the gear driven crusher, the gears are subjected to very hard service. Dust rings are fitted about the shaft where it enters the gear case and all openings are covered, but despite all these precautions a certain amount of dust

and finely broken rock will find its way into the gear case, to contaminate the gear lubricant.

This latter must, therefore, not be too thin or low in viscosity, for in this case the film developed on the gear teeth will not have sufficient body to prevent grit from coming into



Courtesy of Bradley Pulverizer Co.

Fig. 8—Assembly of roll in the Bradley Hercules Mill. It is interesting to note that this is an oil lubricated roll, the lubricant being circulated via suitable grooving in the base of the roll shaft. Oil should be carried to a depth of sixteen inches, being added through the top of the roll.

actual contact with the gear teeth as they pass into mesh. This, of course, would lead to abrasion and wear.

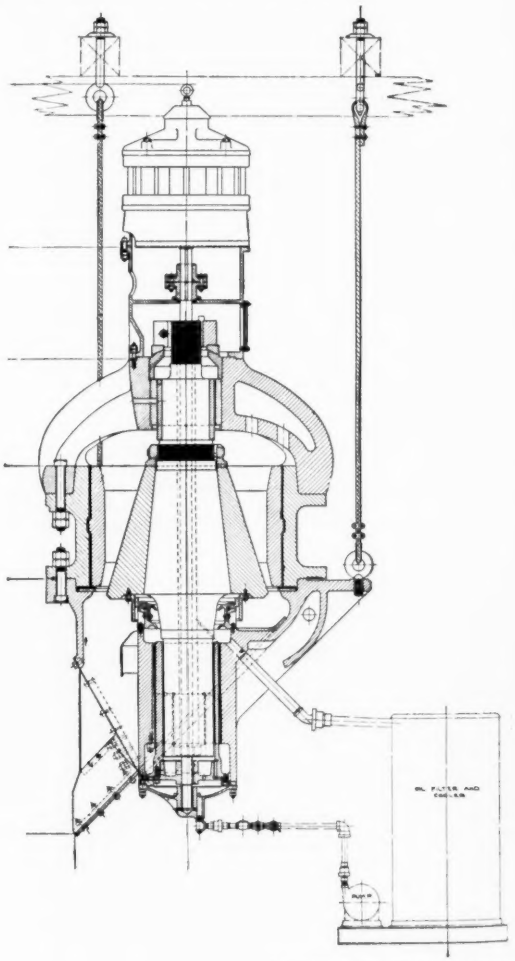
As a result, the lubricant used upon these gears should be carefully selected. As a general rule, a straight mineral oil of from 90 to 145 seconds Saybolt at 210 degrees Fahr. will give the best results.

Such an oil will, furthermore, resist the drying action of the dust and prevent its packing between the teeth of the gears, thus obviating any tendency in the latter to spring and throw unnecessary pressure upon the countershaft bearings and the eccentric. Where a crusher may have to operate in cold weather, the lubricant used upon the gears must also have a low pour test to insure proper fluidity in the oil. This will reduce drag, power consumption and the possibility of wear.

The Eccentric

That part of a gyratory crusher, however, which will require the greatest amount of attention from a lubrication point of view, is the eccentric which imparts the gyratory motion to the shaft.

As the eccentric revolves within a bushing and about the shaft, there are two surfaces to be lubricated. In addition, there is the brass wearing ring which carries the weight of the bevel gear and eccentric. In some machines, furthermore, the bottom of the shaft is designed to fit very loosely in the eccentric in order that it may be tipped from side to side. This throws all the pressure upon a small area near the top of the thickest part of the eccentric sleeve, causing it to heat and wear rapidly unless properly lubricated with the right oil.



Courtesy of Allis-Chalmers Mfg. Co.

Fig. 9—Sectional view of a Newhouse Crusher. This is a gearless gyratory type of machine, with the eccentric operated by a vertical motor on top of the spider. Automatic circulation of lubricating oil is provided for by means of a motor driven centrifugal pump. A combination filter, cooler and tank is also provided as shown.

Positive Lubrication Essential

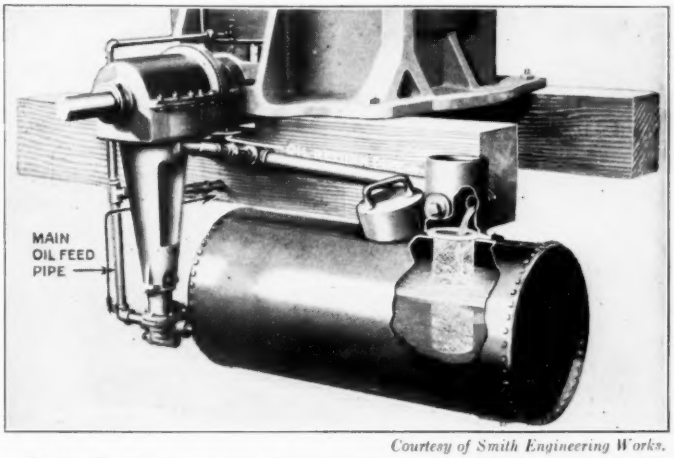
Automatic lubrication, whereby the oil is circulated under pressure throughout these mechanisms, is becoming practically standard on all such equipment, due to the absolute

necessity for continued and dependable maintenance of a sufficient flow of oil to not only withstand the pressures involved, but also to remove any excess of heat developed.

Operation of the Oil Pump

This is brought about by means of a suitable oil pump which is located at the bottom of the crusher, either within or adjacent to the oil reservoir or chamber in the bottom plate. An ample supply of oil of from 30 to 100 gallons is contained in the system, which as a rule includes a suitable filter or strainer through which the oil passes at each circulation.

This, together with the general dust-proof construction of the modern gyratory, insures against the entry and circulation of an excess of dust through the system. As a result, all the lower wearing parts are served with a flood of clean, cool oil throughout the period of operation of the gyratory crusher, for by virtue of the nature of the design and construction, the oil pump starts simultaneously with the latter, operating at a speed commensurate with the rate of crushing.

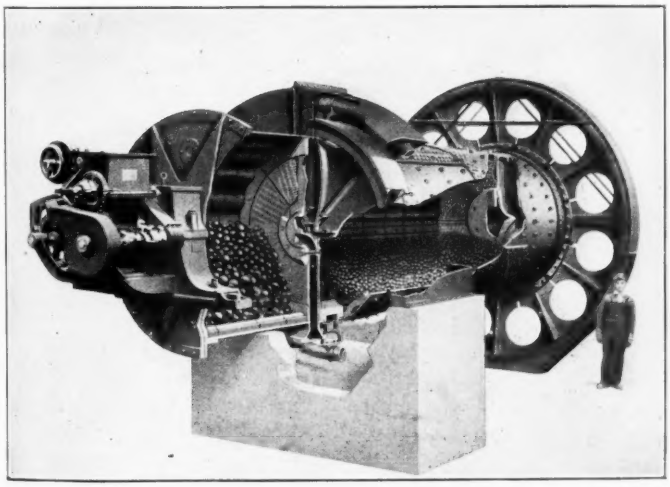


Courtesy of Smith Engineering Works.

Fig. 11—Showing the gear type oil pump employed on the Telsmith primary breaker. Note the oil feed line, return pipe and strainer. This device affords full pressure lubrication to all gears and bearings of the crusher.

Use of Cooling and Heating Coils

Under normal conditions of crushing, provided the system has an ample oil capacity, overheating will not usually present any difficulty. Where hard rock is to be crushed, however, during very hot weather, it will be found advantageous to provide for cooling the oil during its circulation. The builders enable this on certain crushers by installing a water cooling coil in the oil chamber itself. Not only does this enable the cooling of used oil, but it also renders cold weather starting more feasible, for steam or hot water can likewise be circulated through such coils to warm up the oil.



Courtesy of Allis-Chalmers Mfg. Co.

Fig. 10—Sectional view of a dry grinding "Compeb" mill. Main bearings of this machine are built with the lower half arranged for water cooling. The cap of each forms a dust shield, as well as an ample chamber for reception of lubricant. This permits of continuous and positive lubrication.

Bath Lubrication

According to the design, the eccentric sleeve operates wholly or partially in a bath of oil, which serves both as a lubricant and a cooling agent.

Where no oil pressure is involved, the crusher speed is relied upon to induce oil circulation by capillary attraction, the oil passing up through the eccentric journal over the brass wearing ring and back through passages to the reservoir beneath the shaft.

This simple oiling system has been found very efficient provided a little fresh oil is added once or twice a day. The reservoir should be drained and cleaned regularly.

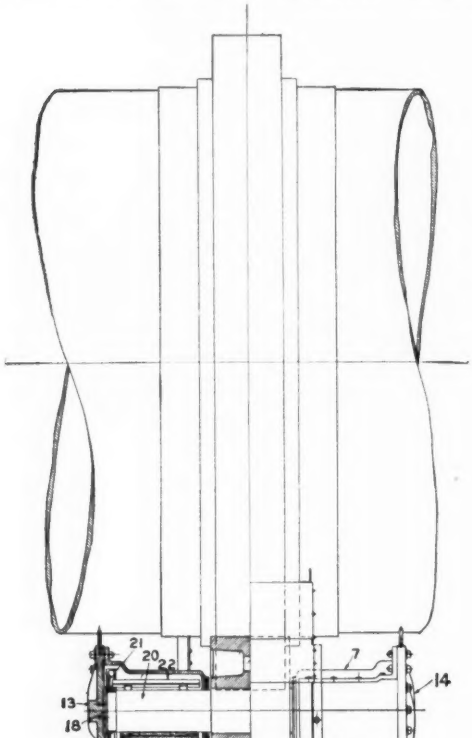
A great deal of trouble will also be avoided if a little oil is forced over the eccentric bearing surfaces of any crusher before the machine is started up. This is especially advisable where crushers are exposed to low temperatures.

Where automatic force feed lubrication is used, the eccentric may be flooded by operating the pump by hand. With machines depending upon capillary lubrication, however, a small hand pump should be provided for flooding. An additional advantage of the

pump is that it may be used to flood the eccentric should it show a tendency to heat.

Choice of Lubricant

For general warm weather lubrication of such equipment in systems as illustrated and dis-



Courtesy of Allis-Chalmers Mfg. Co.

Fig. 12—Side view of the two-roll carrying mechanism for Allis-Chalmers rotary coolers and dryers. It is interesting to note from the sectional view that the bearings are water cooled and self-oiling. No 21 indicates the bearing oiling wheel rotated by the end of the trunnion shaft. This wheel carries suitable cups which dip into the oil at each revolution. As they reach the top of the bearing, they empty their oil into the bearing pan shown as No. 22.

cussed above, a straight mineral oil of from 90 to 145 seconds Saybolt viscosity at 210 degrees Fahr. will usually give the best results.

In cold weather, however, it will always be advisable to resort to an oil of lower viscosity, especially if there is no provision (in the form of cooling or heating coils) in the system for heating the oil prior to starting or during operation. Usually a viscosity of from 500 to 750 seconds Saybolt at 100 degrees Fahr. will be best where a lighter oil is required, according to the necessity for lower pour test and greater fluidity, especially on starting.

Top Bearings and Rings

The top bearings, suspension and wearing rings within the dust or spider cap at the top of the main shaft of the average gyratory crusher will also require considerable care in lubrication. Essentially, a product must be chosen which will not run prematurely through the bearings, to leave their surfaces susceptible to excessive friction and wear. As a general rule, crusher oil can be used for such service or light to medium cup greases.

TUBE MILLS

Mills of this type may be known as ball tube, or compartment mills, according to their size and design. They are especially adaptable for final grinding due to the highly uniform product of which they are capable.

The ball mill is essentially a horizontally revolving steel drum partially filled with steel balls which continually roll to the bottom of the drum, grinding the particles of rock between and beneath them.

The tube mill is very similar to the ball mill. It is larger, however, and is designed for finer grinding.

The compartment type of mill, in turn, is a device which combines both the ball and tube mill in one cylinder.

Mills of this type are usually motor driven through enclosed reduction gears.

Operating Conditions

Mills which are carried upon horizontal shafts are difficult to lubricate because of the great weight borne by the shaft, and the fine grit or dust which may get into the bearings.

Every possible precaution is, of course, taken to keep this dust out of the bearings, but it always seems to get in somehow and is frequently the cause of their rapid destruction.

The main shaft bearings are always built large so that the unit loads are not excessive, but in spite of this it is necessary to use a lubricant possessing considerable body in order to prevent undue frictional heat.

Pinion Shafts

Where the pinion shafts of such mills are carried by ring-oiled bearings, a comparatively light bodied oil of from 200 to 300 seconds Saybolt viscosity at 100 degrees Fahr. will normally give satisfactory service. Care should be taken to clean out the reservoirs frequently and to add fresh oil to make up for that lost.

DRYING AND BURNING

Cement rock, after it has been subjected to preliminary crushing, or grinding, must be freed of any contained moisture before it can be finally reduced to a powder. From the crushers it is, therefore, carried to the rotary dryers, or, in some plants, directly to the kilns.

Dryers are large cylinders, four to ten feet in diameter, and from forty to eighty feet in length. They are located on a slight incline to overcome backward thrust.

A fire is maintained at the lower end by means of fuel oil, gas, or coal, the hot gases being blown through the dryer. Dryers are supported on two riding rings and driven by a pinion which engages a girth gear surrounding the barrel.

Burning Kilns

Final calcining is necessary after the raw material has been subjected to adequate grinding. Rotary kilns are used for this purpose. Their distinct function is to fuse the pulverized raw materials preparatory to final grinding.

Dryer Operating Conditions

As dryers revolve only four to six times a minute, speed does not create any unusual lubricating problems. Bearing and gear tooth pressures, however, are comparatively high, for heavy loads must be carried. Furthermore, there is always possibility of difficulty due to the ever-present dust and the heat which is radiated from the dryer. By reason of this, the trunnion bearings will frequently run hot. As a result, grease lubrication has been found to be very satisfactory.

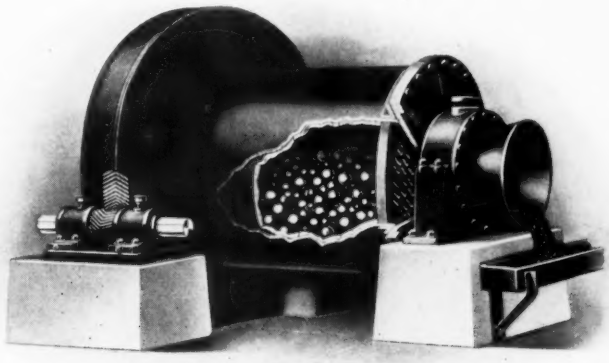
It is also practicable, however, to lubricate such parts with heavy oil, dependent upon the means for application, especially where grit can be kept out of the bearings.

Regardless of the type of lubricant, however, it is important to remember that whenever the maintenance of high temperatures is essential, the radiated heat may thin down certain lubricants to such an extent as to seriously reduce their lubricating ability.

Kiln Lubrication

Rotary kilns, in turn, may be said to present one of the most difficult lubricating problems of the cement plant. With the exception that three or more riding rings are used upon some of the larger kilns, and that the construction is generally heavier, the carrying, thrust and driving mechanisms of the average kiln are the same as those of the dryer.

Lubrication is not as readily maintained, however, due to the extremely high temperatures within the kiln. These naturally cause the shell to become very hot, this heat being radiated to the driving and supporting machinery. The girth gears, for example, will oftentimes become so hot as to reduce some lubricants to the consistency of water.



Courtesy of Kennedy-Van Saun Mfg. & Eng. Corp.

Fig. 13—Cut-away view of a Kennedy-Van Saun Ball Mill, showing in particular the enclosed herring-bone gear drive. The bearings of this mill are of the roller type. Note in particular the ample diameter of the bearing at the discharge end of the mill.

The Driving Mechanism

The general matter of gear lubrication must, therefore, be given very careful attention. This is especially true where operators have been accustomed to believe that black oils are satisfactory lubricants. Frequently they might be —for dryer service—but they will normally be quite unsuited for the higher temperatures found on the average kiln.

It must also be borne in mind that dust and grit aid high temperatures in drying up a lubricant. As a result, only a specially prepared product of pronounced adhesiveness, having a high liquefying point and considerable body, will be capable of preventing metallic contact and providing efficient lubrication.

Trunnion Bearing Lubrication

Bearings of the trunnion type present one of the most difficult lubricating problems in the entire cement plant.

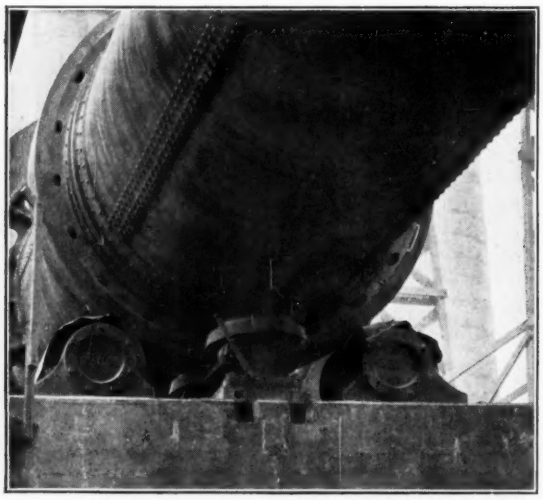
This is due to the fact that

1. Comparatively heavy loads must be carried,
2. The trunnions often become heated, due to their proximity to the shell, and
3. Considerable dust and grit may find their way between the bearing surfaces.

The essential remedy for all of these troubles is a grease or oil possessing considerable body and a high liquefying point. On the other hand, it is practicable to effect a certain amount of

temperature reduction by making provision for cooling water circulation.

Trunnion bearings are generally of large size. Furthermore, in view of the fact that all the thrust is downward, certain types of bear-



Courtesy of Traylor Eng. & Mfg. Co.

Fig. 14—The underside of an eleven foot three inch by two hundred foot kiln, showing the thrust roll and plain support rolls. These are equipped with Timken roller bearings.

ings are very often lined on the bottom half only; this lining can be readily replaced when worn. Inasmuch as the caps of such bearings carry no lining, they merely serve as dust shields and receptacles for the lubricant.

Self-Oiling Bearings

In connection with trunnion bearings it is interesting to note that considerable study has been given to the development of means for automatic lubrication, the bearings in this case being of the two-part type, with a cap lined in very much the same manner as a standard type of plain bearing. Oil is carried in a suitable reservoir below the bearing, being distributed by a dipper device which is rotated by the shaft.

Normal construction is to provide two of such dippers which at every rotation automatically fill themselves with oil to empty same along the top of the shaft. From this point oil is distributed throughout the entire clearance space. These bearings are normally water-cooled; as a result it is not essential to resort to an extremely heavy-bodied lubricant.

By reason of their construction, and the ample oil supply available, they insure effective lubrication to a high degree. There is but little opportunity for entry of abrasive foreign matter, and the fact that the bearings are flooded with oil insures that any dust or dirt which may be present will be flushed out from the clearance space by the oil.

Roller Bearings

The roller bearing has also been adapted to trunnion design, with evidence of being quite as advantageous as the self-oiling plain bearing. As a general rule, however, the roller bearing will not have as ample a lubricant reservoir. Furthermore, there may be provision for oil or grease lubrication, according to the design and the provisions made for application by the builders.

Wick Oilers

A decided advancement in the lubrication of trunnion bearings has been the adoption of wick feed oilers. These latter, by virtue of the fact that they assure more positive lubrication, will render operation more dependable through reduction of bearing wear. This will, of course, lead to reduced maintenance and repair costs.

Wick oilers are particularly adaptable to existing installations, due to their low first cost and the ease with which they can be substituted for more crude means of lubrication.

More attention, however, may be required with such a means of lubrication, for the cups must be refilled with a few ounces of oil about twice daily, whereas with grease lubrication certain cups or boxes will carry sufficient lubricant for a week or more.

Regular examination of such oilers is advisable in order to check any possibility of oil carbonization at the bend of the wick. This will be especially apt to develop on bearings adjacent to the firing end of a kiln. If allowed to continue, carbonization may impair the flow of oil through the wick to the bearing. It can, however, be corrected by rubbing of the wick between the fingers.

Courtesy of Allis-Chalmers Mfg. Co.

Fig. 15—Exterior view of a kiln carrying and thrust mechanism. The thrust mechanism is usually located on the upper roll frame with a thrust or guide roll on each side of the tire or riding ring, to prevent the shell from sliding too far upwards or downwards along the rolls.

Pressure Also a Factor

The pressure involved must always be considered. The great weight of the larger kilns combined with the radiated heat creates a lubricating problem which may often require

special attention. Where trunnion bearings are water-jacketed, lighter lubricants may be used with good results, but when cooling is not provided for these products often become too thin to keep the bearing surfaces apart. In such cases, unless wick feed cups or self-oiling devices are provided, the cavities in the bearings should be packed with a comparatively heavy fibrous grease.

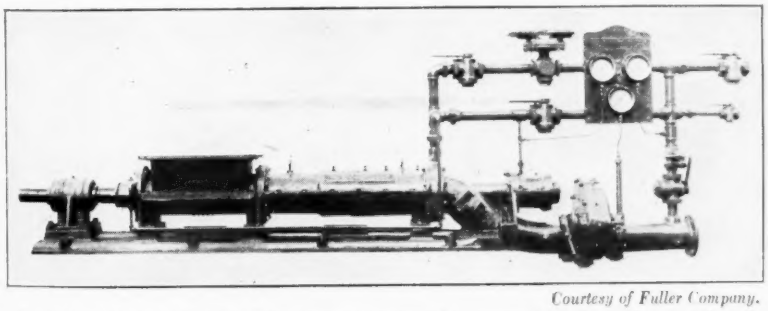
Clinker Coolers

The fused materials issue from the kiln in the form of white hot clinkers which are either conveyed to a storage pile or cooled at once for grinding. Cooling may be effected at the discharge end of the kiln or the material may be passed through an individual cooler. The clinker cooler, where it is a separate unit, is so similar to the dryers and kilns that it requires no further description.

While but little heat is actually radiated from this machine, the riding rings and girth gears will oftentimes get quite warm through conduction. A lubricant having a fairly high liquefying point should, therefore, be used. It must also, of course, resist the cutting and drying action of the inevitable dust. Lubricants suitable for the dryers should prove satisfactory upon the corresponding parts of the clinker coolers.

CONVEYING EQUIPMENT

The actual handling of cement materials in passage to or from the various crushing devices, dryers and kilns is accomplished by use of the screw or flight conveyor, or by a suitable pressure pumping system.



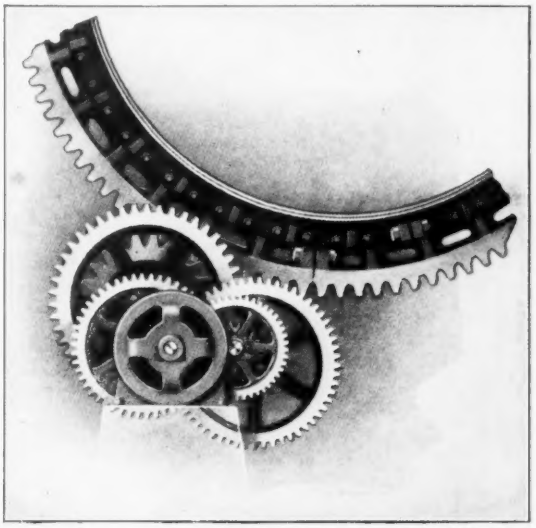
Courtesy of Fuller Company.

Fig. 16—Side view of a Fuller-Kinyon conveying system for transporting pulverized cement through pipe lines for a distance up to several thousand feet. The operating element is a pump which forces the material through the pipe line under pressure. This pump is mounted on Fafnir ball bearings. Normal lubricating requirements will necessitate use of a grease capable of functioning under high operating temperatures.

Lubrication a Factor

In the operation of such equipment, the essential points to guard against will be neglect and disregard for the importance of lubrication. Every consideration should be given to the fact that high temperatures, and frequently considerable thrust pressure, may be involved.

Furthermore, there will usually be a considerable amount of dust present, and in the case of mechanical conveyors, the wearing elements may be exposed to a sufficient extent to permit of entry of enough abrasive foreign matter to cause considerable wear. This will be especially true on certain types of conveyor roll bearings. For this reason some builders have made special effort to design their equipment of as nearly oil and dust-tight a nature as possible.



Courtesy of Kennedy-Van Saun Mfg. & Eng. Corp.

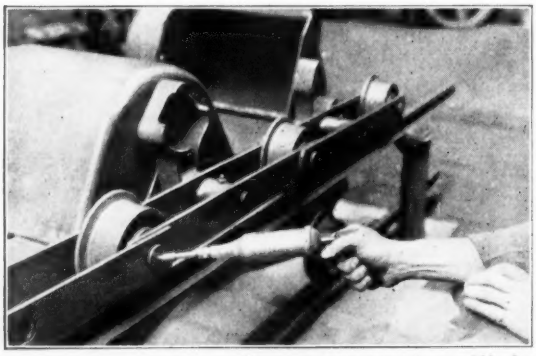
Fig. 17—The driving gears for a rotary kiln. Note in particular the contrast in size between the teeth of the pinions and those of the girth gear. Due to the normally high load which must be carried; careful attention must be given to selection of a gear lubricant of sufficient adhesiveness to adequately prevent wear of the teeth.

Types of Lubricants

Both grease and oil are acceptable lubricants, according to the design of such parts. Certain types of rollers, for example, will require oil, a suitable wick being used as a distributor. In such devices a straight mineral oil of from 300 to 500 seconds Saybolt viscosity at 100 degrees Fahr. will be satisfactory. In general, such an oil will also be adaptable for the lubrication of the driving motor bearings of either ring oiled or anti-friction type, provided the housings will retain oil and temperature conditions are not abnormal.

Other types of conveyor rollers are designed for grease lubrication, being equipped either with compression cups or pressure grease fit-

tings. Unless the bearings of such rollers are relatively dust-proof, grease will be the more satisfactory lubricant, for it will serve as an effective seal at the rims of the bearings to prevent entry of dirt or dust. The usual pro-



Courtesy of Stephens-Adamson Mfg. Co.

Fig. 18—Showing means of lubricating conveyor rolls by means of a hand pressure grease gun.

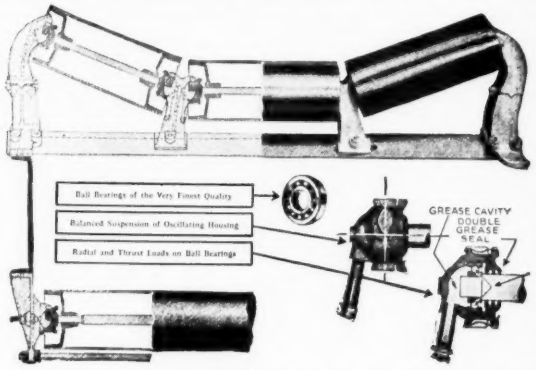
cedure in lubricating such rollers is to screw down the compression cup tops, or continue to force in grease with the pressure gun until there is a slight efflux at the edges of the bearings.

High Temperature Requirements

Under higher temperature conditions, however, a relatively high melting point grease, as used on certain of the kiln trunnion bearings, should be used.

This question of temperature must frequently be given especial attention in the lubrication of the ball bearings of pumps, which are used to force the materials through pipe lines for a considerable distance under pressure. Such means of conveying pulverized products is particularly adaptable to the cement industry.

Wherever the pump bearings are subjected to considerable heat as, for example, where flue



Courtesy of Stephens-Adamson Mfg. Co.

Fig. 19—Details of belt conveyor construction, showing in particular the ball bearings employed and the construction of the multiple groove grease seal for the purpose of preventing entry of abrasive foreign matter.

dust or hot cement must be handled, every attention should be given to the selection of a grease of adequate melting point and consistency, to withstand the thinning down effects of the temperatures involved.

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